

# Extension of the known geographic distribution of Greenhall's Dog-faced Bat, *Cynomops greenhalli* Goodwin, 1958 (Chiroptera, Molossidae): first records in Costa Rica

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## Abstract

Specimens of the Neotropical dog-faced bats of the genus *Cynomops* Thomas, 1920 are poorly represented in museum collections, and the geographical distributions of the eight species are not well known. We report voucher specimens that confirm the presence of *C. greenhalli* Goodwin, 1958 in the Tropical Wet Forest of Costa Rica. These specimens represent an extension of the distribution into the Caribbean Central America.

## Keywords

Caribbean slope, Central America, Costa Rica mammals, free-tailed bats, range extension, Tropical Wet Forest.

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## Introduction

Molossidae is the fourth most diverse family of bats (Chiroptera) worldwide, with 22 genera and more than 126 species which mostly occur in tropical regions (Loureiro et al. 2018; Taylor et al. 2019). Molossids are high-flying insect-hunting species; they are difficult to catch with ground-level mist-nets, which are the traditional and most commonly employed method in bat inventories (Reid 2009; Arias-Aguilar et al. 2018; Moras et al. 2018). However, the use of mist-nets set over water bodies and in the canopy is a good method to capture these bats (Muñiz-Martínez et al. 2003; Ruiz-Gutiérrez et al. 2011; Villalobos-Chaves et al. 2018; Taylor et al. 2019). The

use of ultrasound detectors to augment mist-net surveys has demonstrated how little we know about the distributions of molossids and other aerial insectivores (Jung et al. 2014; Arias-Aguilar et al. 2018).

The dog-faced bats of the genus *Cynomops* Thomas, 1920 are fast-flying, aerial insectivores that have been recorded in a variety of habitats, including disturbed and fragmented forest areas (Jung and Kalko 2011; Bader et al. 2015; Moras et al. 2018). Species of *Cynomops* occur from northern Mexico to northern Argentina, including Trinidad and Tobago (Muñiz-Martínez et al. 2003; Moras et al. 2018; Taylor et al. 2019). However, material



of *Cynomops* collected and deposited in museums is scarce, and the distribution of all eight currently known species remains poorly known (Moras et al. 2018).

*Cynomops greenhalli* Goodwin, 1958 has a broad distribution on both sides of the Andes, ranging from Panama to Ecuador, Venezuela, and Trinidad and Tobago (Moras et al. 2018). However, Taylor et al. (2019) recently re-identified as *C. greenhalli* a few specimens from Costa Rica and other localities towards northern Central America that were previously identified as *C. mexicanus* Jones & Genoways, 1967.

Herein, we revise the specimens of *Cynomops* deposited at the Mammal Collection of the Museo de Zoología de la Universidad de Costa Rica and report two new localities for Greenhall's Dog-faced Bat, *C. greenhalli*, that expand its known range, and confirms the species' presence in Costa Rica.

## Methods

We revised nine specimens belonging to the genus *Cynomops* and identified seven of them as *C. mexicanus* and the other two (reported here) as *C. greenhalli*. The first specimen of *C. greenhalli* was collected in La Selva Research Station, located on the Caribbean slope at the northeastern edge of the foothills of the Central Volcanic mountain range. La Selva encompasses 16 km<sup>2</sup> (35–137 m a.s.l.) of Tropical Wet Forest (Holdridge 1967) divided in to old-growth and second-growth, and it is connected to the Braulio Carrillo National Park by a 5–10 km wide corridor along its southern boundary. The surrounding land has been cleared up for pastures and plantations. The specimen collected on 27 June 1993 was fixed in 10% formalin and then preserved in 70% ethanol. It was originally identified as *Molossops greenhalli* and later classified as *Cynomops mexicanus*.

The second specimen of *C. greenhalli* came from Veragua Rainforest, located in the Central Caribbean of Costa Rica, on the northern edge of the Matama mountains, in the Talamanca mountain range. This private reserve fits the description of the Basal Tropical Wet Forest life zone (200–600 m a.s.l.) according to Holdridge (1967). It comprises mature forest, secondary vegetation at different stages of regeneration, open areas, and dirt roads. This area is the point of the Talamanca mountain range that is closest to the Caribbean Sea and it forms part of the buffer zones of La Amistad International Park (UNESCO World Heritage Site). The water bodies that drain from the region are part of the Banano, Zent, Peje, and Chirripó river basins. A single female individual of *C. greenhalli* was collected on 24 October 2019. The flying animal was spotted and seen crashing into the greenhouse mesh and falling to the floor of the open area of an infrastructure used for meals and resting. The voucher specimen was collected with permission from the National System of Conservation Areas (Resolución No. R-SINAC-PNI-ACLAC-050-2018) following the standards of the American Society of Mammalogists

(Sikes et al. 2016). The specimen was prepared as a dry skin with skull and skeleton separated.

We recorded external and skull measurements in millimeters (mm) using digital calipers accurate to 0.01 mm; and body mass is taken in grams (g). Measurements were based on, but not restricted to those described in Freeman (1981) and Moras et al. (2016): total length (ToL), tail length (TaL), ear length (EL), hind foot length (HFL), forearm length (FL), body mass (BM), greatest length of skull (GLS), braincase breadth (BB), and post orbital breadth (POB). For tooth nomenclature, we followed Giannini and Simmons (2007) and Gregorin and Cirranello (2015) in considering the lower premolar arrangement of p1, p4, and p5 for molossids. The identification was based on Moras et al. (2018). The vouchers are deposited at the Mammal Collection of the Museo de Zoología de la Universidad de Costa Rica (UCR), San José, Costa Rica.

## Results

### *Cynomops greenhalli* (Goodwin 1958)

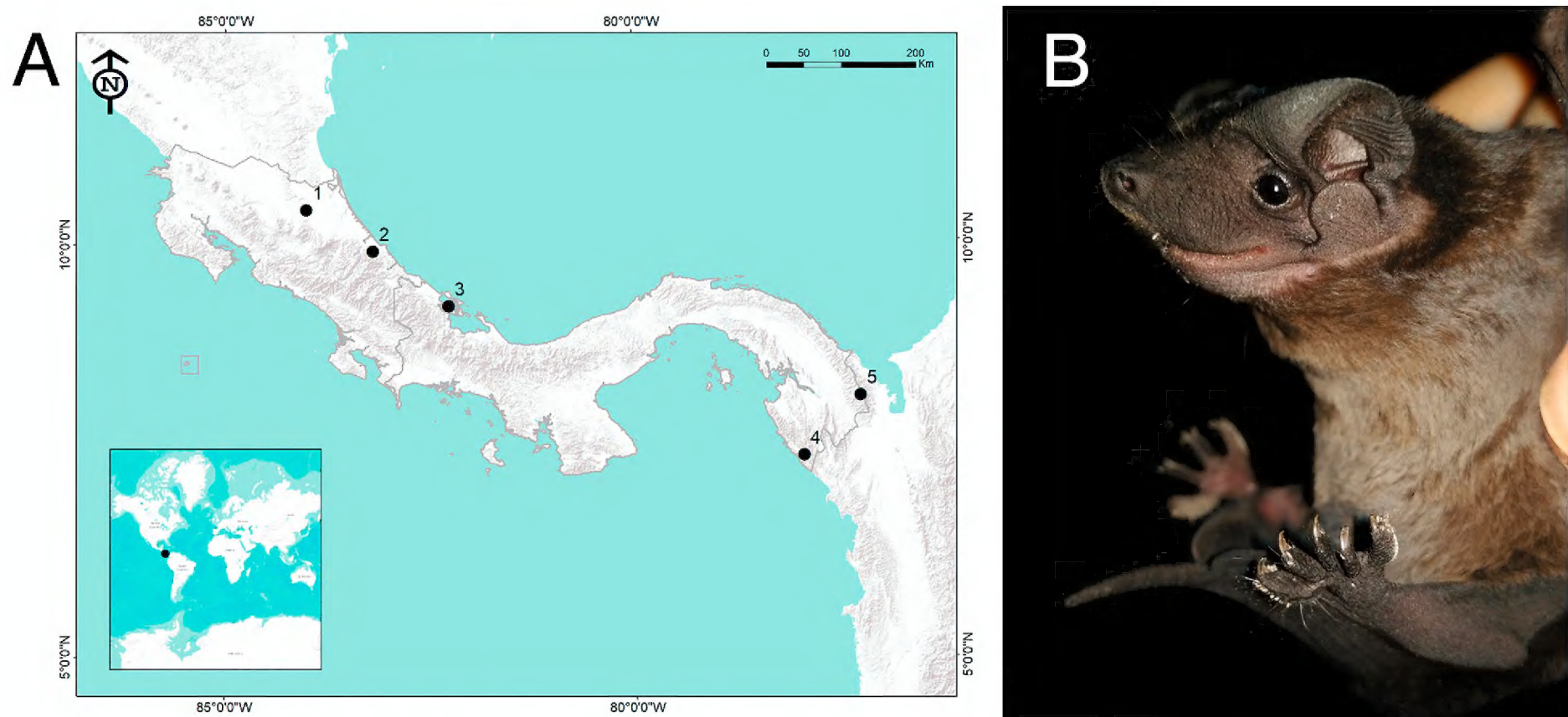
**Materials examined.** COSTA RICA • 1 adult ♀, ToL 69, TaL 33, EL 14, FL 38, BM 21; Heredia Province, Puerto Viejo district, La Selva Research Station; 10°25'48"N, 084°00'23"W; 60 m a.s.l.; 27 Jun. 1993; J.M. Mora leg.; UCR 4802 • 1 adult ♀, ToL 66.4, TaL 31.5, EL 13, HFL 8.2, FL 36.8, BM 17.9, GLS 17.70, BB 9.38, POB 5.20; Limón Province, Río Blanco district, Brisas de Veragua, Veragua Rainforest; 09°55'30"N, 083°11'28"W; 420 m a.s.l.; 24 Oct. 2019; D. Salas-Solano leg; UCR 5043.

**Identification.** *Cynomops greenhalli* can be distinguished from other *Cynomops* species by the size of the forearm. The only congener with overlapping measures is *C. mexicanus*, but this species can be distinguished by its pattern of ventral pelage coloration. In both species, the venter is slightly paler than the dorsum, but in *C. greenhalli* the general ventral pelage is more whitish in the gular to mid-ventral region (Fig. 1B), whereas in *C. mexicanus* the ventral pelage is much paler than the dorsum. *Cynomops mexicanus* also has a bright white venter along the entire mid-ventral region. *Cynomops greenhalli* has a well-developed median ridge on the lingual face of the second lower premolar (vestigial or absent in *C. mexicanus*), and it has a shallow fossa in the posterior squamosal bone where the zygomatic arch meets the braincase (deep in *C. mexicanus*) (Fig. 2A). Also, in *C. greenhalli* the first lower premolar (p4), is two-thirds or more of the height of the second lower premolar (p5), but in *C. mexicanus*, the first lower premolar (p4) is a half or less of the height of the second lower premolar (p5) (Fig. 2B).

## Discussion

Only *Cynomops mexicanus* has been previously reported as occurring in Costa Rica, where it was restricted to





**Figure 1.** Geographical information and live specimen of *Cynomops greenhalli*. **A.** Distribution of *C. greenhalli* in Costa Rica and neighboring localities. 1, 2. First records from Costa Rica: (1) Heredia, Puerto Viejo, La Selva Research Station (UCR 4802); (2) Costa Rica, Limón, Brisas de Veragua, Veragua Rainforest (UCR 5043). 3–5. Records from Panama based on specimens deposited in the National Museum of Natural History, Smithsonian Institution (USNM): (3) Bocas del Toro, Isla San Cristóbal (USNM 449875); (4) Darién, Jaqué, Rio Imamado (USNM 363108); (5) Darién, Tacarcuna Village Camp (USNM 310264). **B.** Rostrum and ventral view of *C. greenhalli* from the Costa Rican specimen (UCR 5043).

the dry forest of the Pacific lowlands, the southern limit of its known geographic distribution (Peters et al. 2002; Pineda et al. 2008; York et al. 2019). Our observations, however, confirm the presence of *C. greenhalli* in Costa Rica, demonstrating that this species occurs in the Tropical Wet Forest and in the Caribbean of Costa Rica. Our findings are the first confirmed records of *C. greenhalli* for the country and extend its distribution northwards in Central America, approximately 230 km from the closest known locality in Panama (Fig. 1A). We suggest that photographs of the specimens showing the diagnostic characteristics can help in the revision and future identification of this rare species.

According to this report and recent confirmations of other mammals in Costa Rica (Rodríguez-Herrera et al. 2014; Ramírez-Fernández et al. 2015, 2020; Villalobos-Chaves et al. 2016, 2018; Woodman and Timm 2017; González-Maya et al. 2017; Sáenz-Bolaños et al. 2019; York et al. 2019), the number of extant mammal species for the country is increased to 261 species, including 121 total species of bat. A future goal should be to generate and analyze acoustic recordings in the country to better understand the distribution and ecology of *C. greenhalli* and other cryptic bat species.

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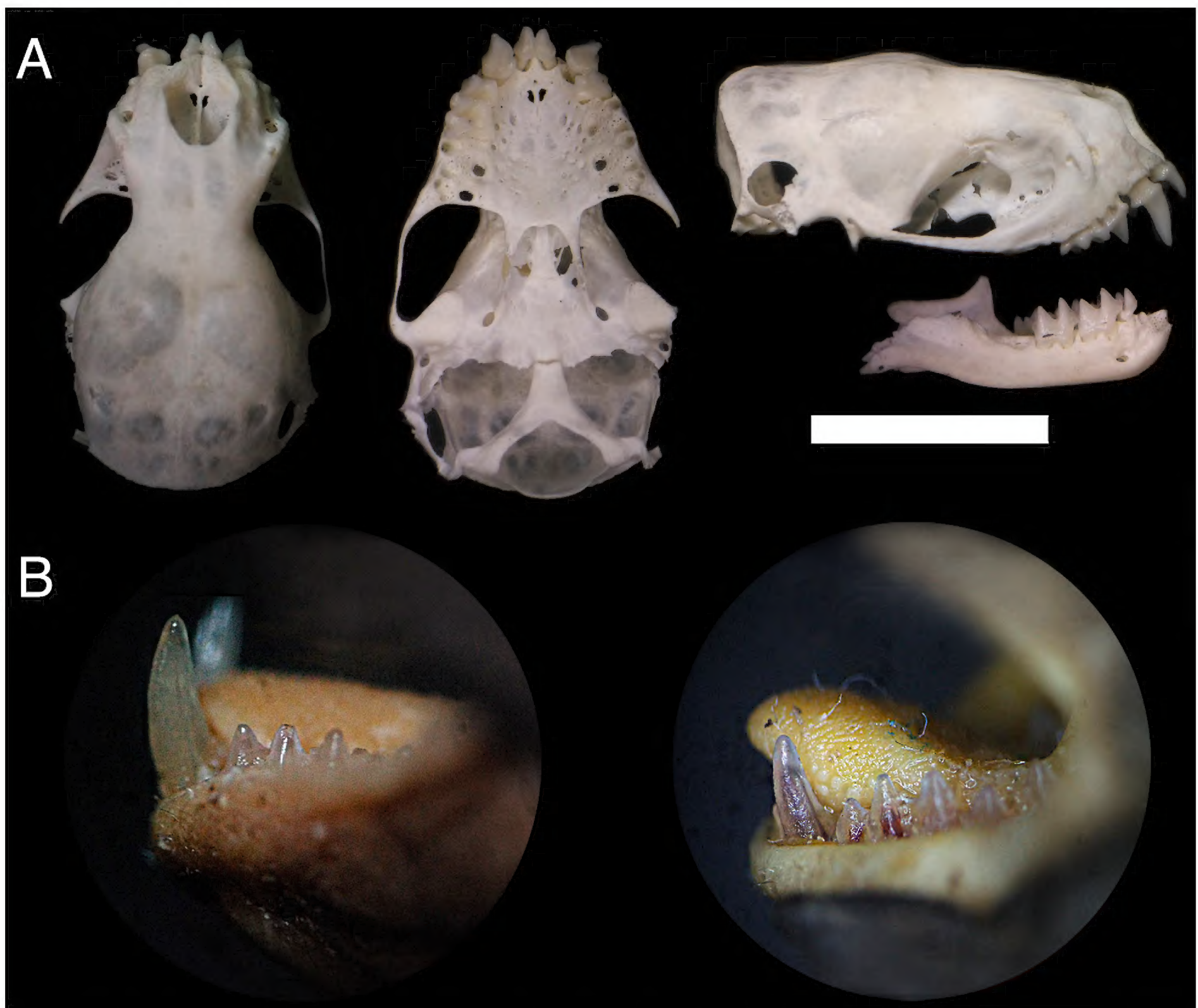
## Authors' Contributions

DSS collected the data. DSS, LMM, and VCT reviewed and identified the specimens. All the authors were involved in the writing, edition, and improvement of the text.

## References

- Arias-Aguilar A, Hintze F, Aguiar LMS, Rufray V, Bernard E, Pereira MJR (2018) Who's calling? Acoustic identification of Brazilian bats. *Mammal Research* 63 (3): 231–253. <https://doi.org/10.1007/s13364-018-0367-z>
- Bader E, Jung K, Kalko EK, Page RA, Rodríguez R, Sattler T (2015) Mobility explains the response of aerial insectivorous bats to anthropogenic habitat change in the Neotropics. *Biological Conservation* 186: 97–106. <https://doi.org/10.1016/j.biocon.2015.02.028>
- Freeman PW (1981) A multivariate study of the family Molossidae (Mammalia, Chiroptera): morphology, ecology, evolution. *Fieldiana Zoology* 7: 1–173. <https://doi.org/10.5962/bhl.title.3128>
- Giannini NP, Simmons NB (2007) Element homology and the evolution of dental formulae in megachiropteran bats (Mammalia: Chiroptera: Pteropodidae). *American Museum Novitates* 3559: 1–27. [https://doi.org/10.1206/0003-0082\(2007\)3559\[1:ehateo\]2.0.co;2](https://doi.org/10.1206/0003-0082(2007)3559[1:ehateo]2.0.co;2)
- González-Maya JF, Gómez-Hoyos DA, Schipper J (2017) First confirmed records of the bush dog (Carnivora: Canidae) for Costa Rica. *Neotropical Biology and Conservation* 12 (3): 238–241. <https://doi.org/10.4013/nbc.2017.123.12>
- Goodwin GG (1958) Three new bats from Trinidad. *American Museum Novitates* 1877: 1–6.
- Gregorin R, Cirranello A (2015) Phylogeny of Molossidae Gervais (Mammalia: Chiroptera) inferred by morphological data. *Cladistics* 31 (3): 1–34. <https://doi.org/10.1111/cla.12117>





**Figure 2.** Cranial characters. **A.** Dorsal, ventral, and lateral views of the skull; and lateral view of the mandible of *Cynomops greenhalli* (UCR 5043). **B.** Lateral view of the lower premolars of *C. greenhalli* (UCR 4802) on the left side, and *C. mexicanus* (UCR 4814) on the right side. Scale bar = 10 mm.

Holdridge L (1967) Life Zone Ecology. Tropical Science Center, San José, 124 pp.

Jones JK, Genoways HH (1967) A new subspecies of the free-tailed bat, *Molossops greenhalli*, from western Mexico (Mammalia: Chiroptera). Proceedings of the Biological Society of Washington 80: 207–210.

Jung K, Kalko EK (2011) Adaptability and vulnerability of high flying Neotropical aerial insectivorous bats to urbanization. Diversity and Distributions 17 (2): 262–274. <https://doi.org/10.1111/j.1472-4642.2010.00738.x>

Jung K, Molinari J, Kalko EKV (2014) Driving factors for the evolution of species-specific echolocation call design in new world free-tailed bats (Molossidae). PloS ONE 9 (1): 1–9. <https://doi.org/10.1371/journal.pone.0085279>

Loureiro LO, Gregorin R, Perini FA (2018) Diversity, morphological phylogeny, and distribution of bats of the genus *Molossus* E. Geoffroy, 1805 (Chiroptera, Molossidae) in Brazil. Zoosystema 40 (3): 425–452. <https://doi.org/10.5252/zoosystema2018v40a18>

Moras LM, Tavares VC, Pepato AR, Santos FR, Gregorin R (2016) Reassessment of the evolutionary relationships within the dog-faced bats, genus *Cynomops* (Chiroptera: Molossidae). Zoologica Scripta 45 (5): 465–480. <https://doi.org/10.1111/zsc.12169>

Moras LM, Gregorin R, Sattler T, Tavares VC (2018) Uncovering the diversity of dog-faced bats of the genus *Cynomops* (Chiroptera: Molossidae), with the redescription of *C. milleri* and the de-

scription of two new species. Mammalian Biology 89 (1): 37–51. <https://doi.org/10.1016/j.mambio.2017.12.005>

Muñiz-Martínez R, López-González C, Arroyo-Cabral J, Gómez MO (2003) Noteworthy records of free-tailed bats (Chiroptera: Molossidae) from Durango, Mexico. The Southwestern Naturalist 48 (1): 138–144. [https://doi.org/10.1894/0038-4909\(2003\)048<0138:nrofbc>2.0.co;2](https://doi.org/10.1894/0038-4909(2003)048<0138:nrofbc>2.0.co;2)

Peters SL, Lim BK, Engstrom MD (2002) Systematics of dog-faced bats (*Cynomops*) based on molecular and morphometric data. Journal of Mammalogy 83 (4): 1097–1110. [https://doi.org/10.1644/1545-1542\(2002\)083<1097:sodfbc>2.0.co;2](https://doi.org/10.1644/1545-1542(2002)083<1097:sodfbc>2.0.co;2)

Pineda W, Rodríguez-Herrera B, Timm RM (2008) Rediscovery, ecology, and identification of rare free-tailed bats (Chiroptera: Molossidae) in Costa Rica. Acta Chiropterologica 10 (1), 97–102. <https://doi.org/10.3161/150811008x331135>

Ramírez-Fernández JD, Córdoba-Alfaro J, Salas-Solano D, Durán A FJ, Rodríguez-Herrera B (2015) Extension of the known geographic distribution of *Diplomys labilis* (Mammalia: Rodentia: Echimyidae): first record for Costa Rica. Check List 11 (5): 1–3. <https://doi.org/10.15560/11.5.1745>

Ramírez-Fernández JD, Durán A FJ, Fernández-Vargas M (2020) First record of Tweedy's Crab-eating Rat, *Ichthyomys tweedii* Anthony, 1921 (Rodentia, Cricetidae, Sigmodontinae), for Costa Rica. Check List 16 (2): 435–440. <https://doi.org/10.15560/16.2.435>

Reid FA (2009) Mammals of Central America and southeast Mexico.



- Oxford University Press, New York, 346 pp.
- Rodríguez-Herrera B, Ramírez-Fernández J, Villalobos-Chaves D, Sánchez R (2014) Actualización de la lista de especies de mamíferos vivientes de Costa Rica. *Mastozoología Neotropical* 21 (2): 275–289.
- Ruiz-Gutiérrez F, López-Damián LJ, Arroyo-Cabrales J, Chávez-Catalán YE, Flores-Sánchez LA (2011) Nuevos registros de Molósidos (Chiroptera: Molossidae) para el estado de Guerrero, México. *Chiroptera Neotropical* 17 (2): 1022–1028.
- Sáenz-Bolaños C, Fuller TK, Mooring MS, Porras J, Sievert PR, Montalvo VH, Carrillo EJ (2019) Bush dogs in central america: recent range expansion, cryptic distribution, or both? *Tropical Conservation Science* 12: 1–5. <https://doi.org/10.1177/1940082919849758>
- Sikes RS, The Animal Care and Use Committee of the American Society of Mammalogists (2016) 2016 Guidelines of the American Society of Mammalogists for the use of wild mammals in research and education. *Journal of Mammalogy* 97 (3): 663–688. <https://doi.org/10.1093/jmammal/gyw078>
- Taylor PJ, Lim BK, Pennay M, Soisook P, Loureiro LO, Moras LM, Kingston T (2019) Family Molossidae. In: Wilson DE, Russell AM (Eds) *Handbook of the mammals of the world*. Vol 9. Bats. Lynx Edicions, Barcelona, 598–673.
- Thomas O (1920) A further collection of mammals from Jujuy. *The Annals and Magazine of Natural History* 9: 188–196. <https://doi.org/10.1080/00222932008632363>
- Villalobos-Chaves D, Ramírez-Fernández JD, Chacón-Madrigal E, Pineda-Lizano W, Rodríguez-Herrera B (2016) Clave para la identificación de los roedores de Costa Rica. *Escuela de Biología, Universidad de Costa Rica, San José*, 37pp.
- Villalobos-Chaves D, González-Quirós A, Lara-Hernández L, Rodríguez-Herrera B (2018) Notes on the geographic range and distribution of two free-tailed bat species (Chiroptera, Molossidae) in Costa Rica. *Check List* 14: 805–810. <https://doi.org/10.15560/14.5.805>
- Woodman N, Timm RM (2017) A new species of small-eared shrew in the *Cryptotis thomasi* species group from Costa Rica (Mammalia: Eulipotyphla: Soricidae). *Mammal Research* 62 (1): 89–101. <https://doi.org/10.1007/s13364-016-0289-6>
- York HA, Rodríguez-Herrera B, Laval RK, Timm RM, Lindsay KE (2019) Field key to the bats of Costa Rica and Nicaragua. *Journal of Mammalogy* 100 (6): 1726–1749. <https://doi.org/10.1093/jmammal/gyz150>